CHICAGO: James William Buchanan, "Control of head formation in planaria by means of anesthetics." John Wood MacArthur, "Comparative study of susceptibility in planaria and other forms by means of electrolytes and vital dyes."

COLUMBIA: Robert Hall Bowen, "Insect spermatogensis. History of cytoplasmic components of the sperm in *Hemiptera.*"

CORNELL: Hazel Elisabeth Branch, "Internal anatomy of *Trichoptera.*" John D. Detwiler, "Biology of three little known clover insects." Dean L. Gamble, "Morphology of ribs and transverse processes in *Necturus maculatus.*" Harry Hazelton Knight, "Insects affecting the fruit of the apple with particular reference to the characteristics of the resulting scars." Rowland Willis Leiby, "Polyembryonic development of *Copidosoma gelechiæ* with notes on its biology." Mortimer Demarest Leonard, "Revision of the dipterous family *Rhagionidæ* (leptidæ) in the United States and Canada." John Thomas Lloyd, "Biology of North American caddis worms." Helen Elizabeth Murphy, "Metamorphosis of may-fly (*Ephemerine*) mouth-parts."

HARVARD: Samuel Wood Chase, "Mesonephros and urogenital ducts of *Necturus maculosus rafinesque.*" William Harder Cole, "Transplantation of skin in frog tadpoles." Emmett Reid Dunn, "Salamanders of the family *Plethodontidæ.*" Cleveland Sylvester Simkins, "Origin and migration of so-called primordial germ cells in the mouse and rat." George Carlos Wheeler, "Larvæ of subfamilies *Dolichoderinæ* and *Formicinæ;* developmental stages of ants."

ILLINOIS: Florence Sander Hague, "Studies on *Sparganophilus Eiseni Smith.*" Ada Roberta Hall, "Effects of oxygen and carbon dioxide on the development of certain cold blooded vertebrates." Ezra Clarence Harrah, "North American Monostomes." Lewis Bradford Ripley, "Morphology and postembryology of *Noctuid* larvæ." Fenner Satterthwaite Stickney," "Head capsule of *Coleoptera.*"

JOHNS HOPKINS: John Graham Edwards, "Effect of chemicals on locomotion in amœba." Alphonse M. Schwitalla, "Influence of temperature on the rate of locomotion in amœba."

MICHIGAN: Horace Burrington Baker, "Distribution of mussels in Douglas Lake."

MINNESOTA: George Henshaw Childs, "Digestive system of diplopods with special reference to parajulus." Samuel Alexander Graham, "Influence of physical factors of the environment on the ecology of certain insects in logs."

OHIO STATE: Carl John Drake, "Ecological and life-history studies of *Heteroptera.*"

PRINCETON: Orren Williams Hyman, "Dimorphism of the spermatozoa of *Fasciolaria Tulipa.*"

RADCLIFFE: Esther Wadsworth Hall, "Braconids parasitic on aphids and their life history."

STANFORD: K. Kunhi Kannan, "Function of the prothoracic plate in *Mylabrid* (Bruchid) larvæ."

WISCONSIN: Sarah Van Hoosen Jones "Inheritance in pigeons; checks and bars and other modifications of black."

YALE: John Spangler Nicholas, "Regulation of posture in the forelimb of *Amblystoma punctatum.*" Leon Stansfield Stone, "Development of the cranial ganglia and the lateral line sense organs in *Amblystoma punctatum.*"

CALLIE HULL
CLARENCE J. WEST
RESEARCH INFORMATION SERVICE,
NATIONAL RESEARCH COUNCIL,
DECEMBER 7, 1921

THE ORGANIZATION OF KNOWLEDGE

II

The aim of all organized knowledge is to increase the certainty of prediction, or as a practical question the science of forecasting, the urgency of which was never more apparent than it is to-day. As has been said by Jevons, "With the progress of any branch of science the element of chance becomes much reduced," for "Not only are laws discovered which enable results to be predicted . . . but the systematic examination of phenomena and substances leads to important and novel discoveries which can in no sense be said to be accidental." The application of this principle to the science of human relations is obvious, yet rarely recognized with the required degree of clearness. A vast amount of human activity continues to be carried on, crude as it may be, in disregard of past experience but of necessity as an adventure or speculation, the evil results of which are most likely to fall upon others than those directly concerned. It is not only

true that "hopeless causes do not always fail" (in the temporary human sense), but that wrongful causes or courses may prove profitable—for a time—and to those directly concerned. It requires to be clearly kept in mind in considering civilization as a science of human relations that in this respect the interests of the individual and society may be diametrically opposed to each other. But just as the police powers control criminal propensities, so the powers of organized knowledge and of demonstrated experience hold in check the reckless intellectual speculations of the audacious but uninformed. In its final analysis the only cure of a fallacy is a demonstrated fact so clearly stated and properly applied that the truth must prevail and prove triumphant.

This conclusion is summed up by President David Starr Jordan in the remark that "The final test of truth is its livableness, the degree to which we trust our lives to it." However much falsehood may prevail and prove an individual advantage—for a time—in the long run it is only "by means of experience, personal and collective, that the human race maintains itself on earth." Such experience, also in the words of Jordan, "concerns itself chiefly with the relations of objects rather than with their ultimate constitution or their intimate nature," for "it gives the truth actually needed in actual life and it furnishes the means for the acquisition of more complete conceptions whenever in the intricacies of life such better knowledge is needed."

The principle here laid down is fundamental to a science of human relations. When the demand arises for practical knowledge, for safe guidance in affairs of business or state, the first essential need is a basis of agreed upon facts, only too often wanting in the case of those who essay upon leadership in the troubled waters of political, economic, or social controversy.

It is likewise with every question, great or small, upon which mankind stands in need of better knowledge to eliminate the prevailing error and misapplication of human effort. Only by organizing knowledge in the manner here suggested will it be possible to secure the future against the vast amount of erroneous conclusions which now hamper progress in practically every important direction in which further progress is most essential for the good of all mankind. No elaborate philosophical treatise on the "Foundations of Knowledge" or the "Human Intellect" meets this need. If typhus is at our door or sleeping sickness no vague advice on preventive measures, however well meaning, meets our needs of the situation or the expectations of the public. No philosophical platitude, no pious phrases of politics held the Indian in his struggle to survive in competition with an unlike civilization in some respects inferior to the moral and physical standards of primitive life.

In very truth it is much easier to evolve speculative theories about knowledge than to ascertain the truth or the facts concerning even the most commonplace matters of every-day existence. Herein lies the conflict between mathematics and statistics and the menace of over-emphasis of the mathematical judgment in matters which are largely questions of facts and not of philosophical inference. Because mathematics are useful—if not indispensable—in astronomy or engineering it does not at all follow that mathematical speculations can safely be applied to problems in biology or vital and social statistics. The practical truths of every-day life are relative and not absolute, all more or less conditioned by the human judgment, totally at variance with the ascertainment of the truth of physics or chemistry. The mode of reasoning most useful in sociology or political science is essentially different from the intellectual concept of accuracy in the transmission of sound waves or the transformation of energy applied to a steam engine or a turbine. Hence I am at a loss to understand the conclusion of Jevons that "As science progresses, its power of foresight rapidly increases until the mathematician in his study seems to acquire the power of anticipating matters and predicting what will happen in stated circumstances before the eye of man has ever witnessed the event." No mathematician gave a forecast of the coming of the great influenza epidemic of 1918-19, no weather

forecast of a coming storm depends upon mathematics, no fall in prices or rise in wages needs the aid of the mathematician to prognosticate events depending largely on unforeseeable contingencies, and finally, no mathematician could have or did forecast the great war and its duration and consequential loss of life and property. But knowledge properly organized would aid enormously in developing the prophetic judgment free from bias or the influence of custom or tradition. Such organization should be the first instead of the last, the most important instead of the most neglected duty of the state. Without it the present chaos and confusion must continue, while the consequences must become more disastrous. Properly organized knowledge on the multitude of matters that concern the state and society would within a single generation do more to advance the cause of true civilization of science and human progress than any other discovery within the realms of possibility.

Nothing that I have said should be construed as opposed to original thought, to the fullest uses of the imagination, lead the conclusions where they may. Such speculations concern the individual and represent opinions which may or may not be accepted as a guide to action in the affairs of every-day life. I am concerned with judgments of a public or universal nature brought forward as a contribution to truth, based upon the ascertained and digested facts of human experience. I agree entirely with Professor Dearborn that it is wrong "to be forever putting facts into the mind while never providing time to use them in thought," and I also agree with his view that "rules for thinking are wholly unnecessary," just as I am convinced of the non-utility of a knowledge of technical grammar in the art of writing. But what belongs to the realm of the imagination is a thing apart in the life of a man who is conscious of his intellectual responsibility in matters of fact and particularly when the facts represent collective experience or conclusions drawn from assembled aggregates usually in the nature of statistical data. No man has a right or a privilege to say that he *knows* what to him is only a matter of belief. On all questions of public policy, where far-reaching consequences are involved in present-day action, it is the first duty of the statesman to make sure of his facts, to clearly differentiate facts from opinion, and to act with absolute impartiality upon the evidence. Accuracy of judgment will be conditioned largely by the state of organized knowledge and its intelligent coordination to the end in view. There is much lip service of coordination in science and government, but a woeful lack of it in practice. To the extent that knowledge is better organized such coordination will become more effective as a matter of course.

Much of what is said here is implied in learned philosophical discussions, failing, however, to emphasize the practical viewpoint as illustrated in every-day experience. Thus the really extraordinary essay on "The System of the Sciences," by the late Professor Ostwald, prepared for the inauguration of the Rice Institute, must needs aid materially the cause of a better method of systematizing knowledge, although failing in the most important particular of outlining a method of classification and arrangement by which the knowledge extant can be made more readily accessible. For illustration, the suggestion that "the ordering of facts and their relationship in each individual science is the first and most important function in its development" is explained as "a discoverer of new facts may not content himself with simply imparting these facts to the world at large, but only after having recognized and fixed them does there arise for him the new great essentially scientific duty of demonstrating the relationship borne by these new facts to the existing order of knowledge in a particular field and of thus rendering them real organic parts of the entire science in question." But this admirable principle is not elucidated as it should have been by some concrete illustration based on extended experience. For while it is perfectly true that "An ordering process of this kind in each particular science has always been the principle of all progress," this conclusion is far from being as clearly recognized as it should be.

Science, in the words of Karl Pearson,

"claims for its heritage the whole domain to which the knowledge can be legitimately applied," and this is amplified by the remark that "knowledge is essentially a description and not an explanation," it being held at the same time that the object of science is to describe in conceptual shorthand the routine of the past. Hence the importance of the fact-gathering process being made as thorough as it is required to be impartial. Pearson properly points out the limitations of Sir Francis Bacon's classification of the sciences, failing in the supreme essential of a "clear distinction between the material of knowledge and knowledge itself, between the real and the ideal, or between the phenomenal world and the unreal products of metaphysical thought."

This discussion of an adequate method of classification is most illuminating, and the different attempts that have been made "show how dangerous it is for any individual to attempt to classify the sciences even if he possesses Spencer's ability." Pearson disavows for his own system the pretense of "logical exactness." For, he remarks, "science is not a mere catalogue of facts, but is the conceptual model by which we briefly resume our experience of those facts." But it would have been to better advantage if these learned conclusions had been illustrated by a few concrete examples, for only in this wise can our actual shortcomings be brought home to us.

From Bacon and Compte to Jevons, Spencer and Pearson, the classification of the sciences has been confused with the organization of knowledge as a prerequisite for an adequate and satisfactory systematic outline of the order of the universe. Pearson's own classification into abstract, concrete, and biological sciences may possibly answer the purpose, but certainly not his amplification that these are united pair and pair "by applied mathematics and biophysics."

More has been claimed for mathematics than for any other branch of science. Granted that "It is the science of exact thought as applied to natural phenomena," it does not at all follow that it is essential or even advantageous in matters in which the approximate truth guides human actions—ever has and ever will, because of the variable conditions which govern our existence or the collective existence of all mankind. No one has essayed upon this question to better advantage than Sir William Hamilton in his discussion on "The Study of Mathematics as an Exercise of Mind." Thus, for illustration, the rather startling observation that "If we consult reason, experience, and the common testimony of ancient and modern times none of our intellectual studies tend to cultivate a smaller number of faculties in a more partial or feeble manner than mathematics." He quotes a German authority to the effect that "We shall first of all admit that mathematics only cultivate the mind on a single phasis. Their object is merely form and quantity. They thus remain, as it were, only on the surface of things without reaching essential qualities or their internal or far more important relations—namely, the feelings and the will—and consequently without determining the higher faculties of activity. So likewise on the other hand the memory and imagination remain in a great measure unemployed."

Sir William Hamilton was of the opinion that mathematics "do not cultivate the power of generalization" and what is even more important as a practical conclusion "the study of mathematics educates to no sagacity in detecting the fallacies which originate in the thought itself of the reasoner." It is of the utmost importance for the present purpose that this conclusion should be clearly grasped. It being held that the inductive process of reasoning, or from the particular to the general, is the only process by which, in the vast majority of cases, conclusions can be correctly arrived at, it must be self-evident that a process of reasoning by pure deduction can not likewise serve the same or a better purpose. Sir William Hamilton makes this point more clear in the statement that "The art of reasoning right is assuredly not taught by a process in which there is no reasoning wrong," or to use his own illustration, "we do not learn to swim in water by previous practice in a pool of quicksilver." The process of fact hunting,

fact assembling, and fact analysis is the prerequisite for fact statements, and it is fact statements alone that are entitled to the serious consideration of those whose judgment and decision affects the present or future welfare of those concerned in the results of the forecasting process.

The organization of knowledge is concerned with the interpretation of the phenomena of every-day experience and not with a theory applied to their interpretation, indifferent to the facts or the nature of the facts considered. This conclusion is admirably set forth by Sir William Hamilton in the words that "Mathematics often afford us no assistance either in conquering the difficulties or in avoiding the dangers which we encounter in the great field of probabilities in which we live." It is, therefore, mere phraseology to say that "The leading characteristic of mathematics is that it deals with properties and ideas which are applicable to things just because they are things and apart from any particular feelings, emotions, or sensations in any way connected with them." (Whitehead). It is precisely the truth that mathematics deals with truth in the abstract that it is so largely inapplicable to questions in which the very best judgment can only represent an approximation to the ideal but nevertheless workable truth. Or, as Sir William Hamilton remarks, "Of observation, experiment, induction, analogy the mathematician knows nothing," yet it is of all these that organized knowledge must take cognizance if it is to serve the useful purpose of advancing the truth by which men live.

I can not for the present enlarge upon this view, recalling, however, the previously quoted remark of Professor David Starr Jordan that "The final test of the truth is its livableness, the degree to which we may trust our lives to it." No theory of probability, however useful in perfecting contingency calculations, can be safely applied to the countless questions upon which facts and mere facts alone will permit of a judgment "to which we may trust our lives." No mathematical figments can make up for deficiencies in knowledge of fundamental truth.

Limitations of space preclude an adequate discussion of the methods pursued in the organization of the library and information service of my office. The methods of organizing knowledge must necessarily vary in detail with the nature of the subject matter, but in my own experience of thirty years I have found no difficulty whatever in gaining a reasonable degree of control over a wide range of essentially different sets of facts and data, systematically arranged upon the principles of easy accessibility, completeness of experience as to time and place and reasonable economy in expense. All general information in my office other than such as is represented by books and pamphlets is first filed under a uniform envelop system arranged, however, in precisely the same manner as the books and pamphlets on the subject index plan.

The classification adopted rests upon the conception that the basis of modern progress is essentially economic, but the term economics is used in the broadest sense and made to include social and allied sciences and activities. The first division of organized knowledge in use in my office bears, therefore, the title "Economics." Under the second division is comprehended "Statistics and Information"; this section is sub-divided into United States and Foreign Countries. Both of these sections are sub-divided into about thirty minor divisions, which readily admit of being enlarged, if occasion should require; but I have found it more advantageous to avoid too many minor sub-divisions, so as to make the indexing of the information as automatic as possible. The fourth section is entitled "Labor and Industry," being practically technological, having to do with all industrial processes, labor conditions, occupational diseases, occupational accidents, etc. The fifth section bears the title "Public Health," but this is limited to the United States, simply as a matter of convenience, for in the general statistical information section public health is Sub-section 8, including, of course, vital statistics. The sixth and last section bears the general title "Science, Medicine and Research," including a vast range of more or less allied subject matters.

Throughout "information" consists chiefly of

newspaper clippings, magazine articles, articles from technical periodicals, etc. Priority throughout is given to original sources of information, including any and all official reports, documents, etc., of value. Aside from the foregoing, there is a section on Graphics, which is becoming a matter entitled to separate consideration, on account of the growing demand for graphic publicity of social, medical and economic experience. As thus conceived, the organization of knowledge can be brought within the compass of six general divisions, which can easily be memorized and into which numerous special sub-divisions fit automatically on the principle of associated ideas.

FREDERICK L. HOFFMAN
PRUDENTIAL INSURANCE COMPANY
OF AMERICA
NEWARK, N. J.

AMERICAN BIOLOGICAL STAINS COMPARED WITH THOSE OF GRÜBLER

IN a recent article[1] the writer called attention to the need of standardizing biological stains now that those of American manufacturers are on the market. In this article mention was made of the fact that the American stains had a rather bad reputation among biologists not necessarily because of their actual poor qualities, but merely because they are different from the Grübler stains which were standard before the war. It was stated at this time that the Society of American Bacteriologists was beginning an investigation of the American stains, and the cooperation of other scientific bodies was urged. Since the article in question was written much cooperation of this kind has been secured and the work has been put on a much broader basis. For this reason it seems well at the present time to insert in these pages a brief report on progress, particularly since many interesting results have already been obtained in comparing the various brands of stains.

Still more recently there appeared in this journal[2] a statement as to a project of the National Research Council on the standardization of biological stains. This work of the National Council is the out-growth of the investigations already made by the bacteriological society. Several of the national scientific organizations, notably the Botanical Society of America and the American Society of Zoologists, are already taking active part in the work. As a result there are now some forty bacteriologists who have taken part in the bacteriological tests of the stains, about fifteen zoologists who are examining certain stains for cytological and other histological work, and it is expected shortly to have a similar group of botanists taking part in the work. The hearty cooperation of all of these investigators, located in many different institutions all over the country, is one of the most pleasant surprises the work has brought out. The tests involved are often quite time-consuming and the willingness of the collaborators to carry them out without question of remuneration or credit for the work is felt to show that biologists in general are keenly interested in the subject. Without their eager cooperation the work would have been impossible, and much credit is due to all of them.

The work has brought out quite plainly that three series of tests are necessary in standardizing any particular stain: first it must be tested for bacteriological staining; second for histological staining; and third its chemical composition must be determined so far as the present status of dye chemistry makes this possible. At present three stains or groups of stains have been tested from the bacteriological standpoint: fuchsin, methylene blue, and the gentian and methyl violets. Of these, methylene blue and gentian violet are now being tested in histological work. In addition to these, histological tests are being made of safranin, hæmatoxylin, orange G and eosine. Chemical work, through the cooperation of the Department of Agriculture in the Color Laboratory, under Dr. Ambler, has been done on methylene blue, and similar tests are shortly

[1] H. J. Conn, The Production of Biological Stains in America, SCIENCE, N. S., 53: 289-290.

[2] The Standardization of Biological Stains, SCIENCE, N. S., 53: 289-290, 1921.